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Cardiac autonomic control during platelet apheresis

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Abstract

Aim: The aim of the current study was to assess the effects of platelet apheresis (PA) on cardiac autonomic control by the means of short-term heart-rate variability (HRV) technique.

Materials and Methods: A total of 100 platelet donors (age: 29.0±0.9 years, body mass index: 25.8±0.7) were evaluated for heart rate (HR), HRV and blood pressure through a full cycle of PA. HR and HRV were assessed by 5-min continuous electrocardiographic recordings at four occasions, i.e., 5 min before (-5 min), and at 10th min (10 min), 45th min (45 min) and at post 5th min of PA. Time- and frequency-domain parameters of HRV were calculated using specific software. Low-frequency (LF)/high-frequency (HF) ratio was also determined. Blood pressure (BP) was also recorded 5 min before and 5 min after PA.

Results: HR increased towards 45th min and declined towards the end of the PA ($P < 0.05$). Both time- and frequency-domain parameters decreased towards the 45th min and increased towards the last 5th mins ($P < 0.05$). LF/HF was increased towards 45th min and declined towards the end of the PA. Systolic BP decreased from 111 (106-120) mm Hg to 107 (99-115) mm Hg (P=0.003).

Conclusions: HR, HRV and blood pressure were dynamically changed throughout the process of PA. These changes appeared to be caused by increased cardiac sympathovagal balance, resembling the pattern observed during whole blood donation.

Introduction

Encouraging more people to donate blood and increasing blood donations from existing donors is and remains a high priority for blood banks worldwide [1]. One of the types of blood donation is platelet apheresis. The procedure applied to apheresis platelet donors is called plateletpheresis [2]. Platelet apheresis is the most common type of apheresis. More than two million apheresis procedures are performed annually in the United States alone [3]. Platelets collected in this way can be given to patients with bleeding or at risk of bleeding [2]. In addition platelet transfusion is performed to prevent the life-threatening complications of thrombocytopenia seen in conditions such as cancer treatment, sepsis and trauma [4].

Blood donation is generally seen as a safe and socially beneficial activity on a voluntary basis [5]. In studies, it has been mentioned that blood donation may have positive effects on donors (increased wellbeing, more alertness, a sense of satisfaction, less migraine, higher physical capacity, respect from environment, feeling of relaxation, increased motivation for health, etc.) [6,7]. In addition, regular blood donation has been associated with a decrease in blood pressure [8], a decrease in lipid levels [9] and a lower risk of cardiovascular disease [10].

Although studies have reported that blood donation induces positive emotions, there is also evidence that there is a psychological stress response due to donation [5]. Stress responses can be categorized into three classes as psychological, physiological and hormonal [5]. In physiological stress responses, usually pulse, systolic and diastolic blood pressure increase and changes in heart rate variability (HRV) are observed [5]. HRV analysis is often used to evaluate the autonomic nervous system (ANS), which functions in cardiovascular research and different practices related to human health [11]. ANS is divided into two groups as sympathetic and parasympathetic. In general,

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sympathetic activity tends to increase heart rate (HR) and decrease HRV, whereas parasympathetic tends to decrease HR and increase HRV [11]. Conflicting results have been found in studies investigating stress responses in blood donors. For example, studies on heart rate prior to blood donation found very different results such as an increase [12], steadiness [13] or a decrease [14]. ANS tightly controls the blood pressures (BP) and HR through its sympathetic and parasympathetic (vagal) branches. During the process of blood withdrawal for transfusion, blood pressure decreases in the donor and this is eventually compensated by increased heart rate.

However, the effect of platelet donation by apheresis on the cardiac autonomic control is not well known. Therefore, the current study aimed to investigate the effect of platelet donation by apheresis on the cardiac autonomic system by means of HRV technique.

Materials and Methods

Ethical consent and participants

The study was carried out in accordance with the ethical guidelines of the 1964 Declaration of Helsinki following ethical approval from the local ethics committee (Malatya Clinical Ethics Committee, No: No 2018/62). After the volunteers were informed about the study, written consent was obtained from them. A total of 100 volunteer platelet donors were included in the study (age 29.0±0.9 years, weight 77.0±1 kg, height 173±1 m, BMI 25.8±0.7). Of the participants included in the study, 24 were women and 76 were men. Healthy volunteer platelet donors aged 18 years or older, who met the standard eligibility requirements for donating platelets, were included in the study.

Experimental design

We performed a cross-sectional study evaluating HRV in platelet apheresis donors at a hospital-based donor center. The participant who came to the blood bank in hospital was rested in sitting position for about an hour, and then 5-minute-long electrocardiography record (for HRV analysis) was taken in supine position. HRV was assessed by 5-min continuous electrocardiographic (EKG) recordings at four occasions, i.e., 5 min pre (-5 min), at 10th min (10 min), at 45th min (45 min) and at post (5 min) of plateletpheresis. Arterial blood pressures were measured before and after the transfusion. Arterial blood pressure was measured indirectly using an automated digital blood pressure monitor (Omron, M6 comfort, China) (Figure 1).

Hemogram and platelet apheresis

In donors, the hemogram parameter is routinely checked by the blood bank. Platelet apheresis process is performed in an average of 45-90 minutes. Trima Accel Automated Blood Collection System was used for the plateletpheresis process. Platelet apheresis being was 'single-needle' procedures. Conditions to be a platelet donor: 1) Being in the age range of 18-65, 2) The pulse should be regular and at a rate of 50-100 beats per minute, 3) He/she should not be a hypertensive patient, systolic blood pressure should not be above 180 mm Hg and diastolic blood pressure should not be above 100 mm Hg, 4) Not having a chronic disease

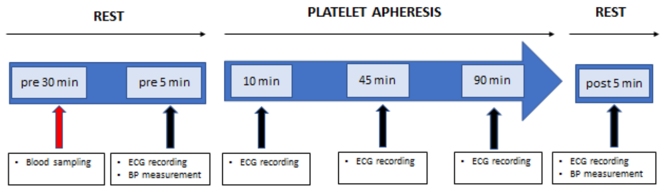

Figure 1. Study flowchart. Measurements in platelet apheresis donors at 5 and 30 min before apheresis (pre 5 and 30 min), at 10th and 45th min during apheresis, and 5 min after apheresis (post 5 min). ECG recordings were taken for 5 minutes. EKG, electrocardiogram; BP, blood pressure.

and not using medication, 5) Hemoglobin level should be above 12.5 (g / dl) in women and 13.5 (g / dl) in men, 6) Having platelet count between 150.000-450.000/mm3, 7) Having negative ELISA test for the screened diseases (hepatitis B, hepatitis C, Human Immunodeficiency Virus and syphilis).

Evaluation of Heart Rate Variability

ECG recordings were taken for 5 minutes in supine positions with eyes open. Poly-Spectrum 8-E was used for ECG record and HRV analysis was made with the HRV software program of the same device (Neurosoft, Ivanovo, Russia). HRV measurement is widely used in the evaluation of the ANS using cardiovascular function (15). All inter-beat intervals were visually checked to ensure that the program recognized them accurately. Resting-state HRV is a psychophysiological phenomenon with broad implications (16). Time domain parameters (HR, SDNN, RMSSD, pNN50 and TP) and frequency domain parameters (VLF, LF, HF, LF/HF, LF norm, HF norm, %VLF, %LF, %HF) were evaluated by using MINITAB statistical package. Time domain parameters: Heart rate, HR (bpm); standard deviation of NN intervals, SDNN (ms); root mean square of successive RR interval differences, RMSSD (ms); percentage of successive RR intervals that differ by more than 50 ms, pNN50(%) and total power, TP (ms^2). Frequency domain parameters: Absolute power of the very-low-frequency band, VLF(ms^2); low-frequency, LF(ms^2); high-frequency, HF(ms^2); ratio of LF-to-HF power, LF/HF; relative power of the low-frequency band (0.04–0.15 Hz) in normal units, LF norm and relative power of the high-frequency band (0.15–0.4 Hz) in normal units, HF norm (17). Arterial blood pressure was measured indirectly using an automated digital blood pressure monitor (Omron, M6 comfort, China).

Statistical analyses

Statistical analyzes were carried out using the program developed by Inonu University Biostatistics and Medical Informatics Department (18). Normal distribution of the data was checked by the Shapiro-Wilk test. One-way, repeated measures ANOVA was used for data having normal distribution but the data with non-normal distribution were compared by Friedman's test. Paired-t test was used for repeated paired measurements (blood pressure).

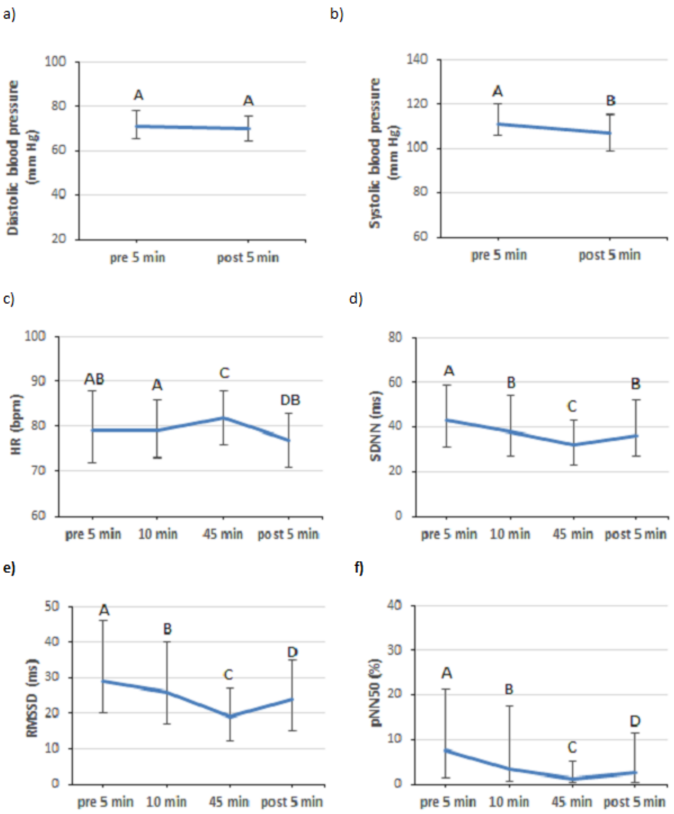

Figure 2. Interquartile range (median, Q1-Q3) for diastolic blood pressure (a), systolic blood pressure (b), HR (c), SDNN (d), RMSSD (e) and pNN50 (f) values in platelet apheresis donors at 5 min before apheresis (pre 5 min), at 10th and 45th min during apheresis, and 5 min after apheresis (post 5 min). Different letters denote significant differences. HR, heart rate; SDNN, standard deviation of NN intervals; RMSSD, root mean square of successive RR interval differences; pNN50, percentage of successive RR intervals that differ by more than 50 ms.

Correlations were carried out by using Pearson's correlation for data having normal distribution Spearman's correlation was used for data that not having normal distribution. Significance was set at $p \leq 0.05$ and the results are shown as interquartile range (median, Q1-Q3).

Results

Arterial Blood Pressure

Mean systolic blood pressure was lower at the post 5 min following completion of the plateletpheresis [107 (99-115) mmHg] compared to the 5 min before starting to apheresis [111 (106-120) mmHg, P=0.003]. Mean diastolic blood pressure was not significantly different between the pre 5 min group [71 (65-78) mmHg, P=0.309] and post 5 min group [70 (64-76) mmHg] (Figure 2 and Table 1).

Time Domain Parameters of HRV

HR (bpm) at pre 5 min [79 (72-88)] was statistically different with 45 min [82 (76-88), P=0.0138]. HR (bpm) at 10 min [79 (73-86)] was was statistically different with 45 min [82 (76-88), P < 0.001] and post 5 min [77 (71-83), P=0.0332] (Figure 1.). SDNN (ms) at pre 5 min 43 (31-59) was statistically different with 10 min [38 (27-54), P < 0.001], 45 min [32 (23-43), P < 0.001] and post 5 min [36 (27-52), P < 0.001]. SDNN (ms) at 10 min [38 (27-54] was statistically different with 45 min [32 (23-43), P < 0.001] and post 5 min [36 (27-52), P=0.1134]. SDNN (ms) at 45 min [32 (23-43)] was statistically different with post 5 min [36 (27-52), P < 0.001] (Figure 1.). RMSSD (ms) at pre 5 min [29 (20-46)] was statistically different with 10 min [26 (17-40), P < 0.001], 45 min [19 (12-27), P < 0.001] and post 5 min [24 (15-35), P < 0.001]. RMSSD (ms) at 10 min [26 (17-40)] was statistically different with 45 min [19 (12-27), P < 0.001] and post 5 min [24 (15-35), P < 0.001]. RMSSD (ms) at 45 min [19 (12-27)] was statistically different with post 5 min [24 (15-35), P < 0.001] (Figure 1.). pNN50 (%) at pre 5 min [7.5 (1.6-21.4)] was statistically different with 10 min [3,2 (0.6-17.5), P < 0.001], 45 min [1.1 (0.3-5.1), P < 0.001] and post 5 min [2.5 (0.4-11.4), P < 0.001]. pNN50 (%) at 10 min [3.2 (0.6-17.5)] was statistically different with 45 min [1.1 (0.3-5.1), P < 0.001] and post 5 min [2.5 (0.4-11.4), P < 0.001]. pNN50 (%) at 45 min [1.1 (0.3-5.1)] was statistically different with post 5 min [2.5 (0.4-11.4), P < 0.001] (Figure 2 and Table 1).

HRV Frequency domain parameters

TP (ms2) at pre 5 min [1728 (925-3136)] was statistically different with 10 min [1368 (672-2726), P < 0.001], 45 min [997 (513-1829)], P < 0.001] and post 5 min [1264 (694-2387), P < 0.001]. TP (ms2) at 10 min [1368 (672-2726)] was statistically different with 45 min [997 (513-1829), P < 0.001] and post 5 min [1264 (694-2387), P < 0.001].TP (ms2) at 45 min [997 (513-1829)] was statistically different with post 5 min [1264 (694-2387), P < 0.001] (Figure 2.). LF/HF (ms2) at pre 5 min [1.9 (1.1-3.2)] was statistically different with 10 min [2.1 (1.2-4.5), P=0.0011], 45 min [3.5 (1.8-5.9), P < 0.001] and post 5 min [2.8 (1.7-5.6), P < 0.001]. LF/HF (ms2) at 10 min [2.1 (1.2-4.5)] was statistically different with 45 min [3.5 (1.8-5.9), P < 0.001] and post 5 min [2.8 (1.7-5.6), P < 0.001]. LF/HF (ms2) at 45 min [3.5 (1.8-5.9)] was statistically different with post 5 min [2.8 (1.7-5.6), P < 0.001] (Figure 2.). LF (ms2) at pre 5 min [580 (262-1196] was statistically different with 10 min [486 (249-945), P < 0.001] and 45 min [430 (227-783), P < 0.001]. LF (ms2) at 10 min [486 (249-945)] was statistically different with 45 min [430 (227-783), P < 0.001] and post 5 min [552 (228-1030), P < 0.001]. LF (ms2) at 45 min [430 (227-783)] was statistically different with post 5 min [552 (228-1030), P < 0.001] (Figure 2.). HF (ms2) at pre 5 min [323 (129-723)] was statistically different with 10 min [221 (89-527), P < 0.001], 45 min [138 (48-287), P < 0.001] and post 5 min [191 (66-500), P < 0.001]. HF (ms2) at 10 min [221 (89-527)] was statistically different with 45 min [138 (48-287), P < 0.001] and post 5 min [191 (66-500), P < 0.001]. HF (ms2) at 45 min [138 (48-287)] was statistically different with post 5 min [191 (66-500), P < 0.001] (Figure 2.). LF norm at pre 5 min [65 (52-76)] was statistically different with 10 min [68 (54-82), P=0.0019], 45 min [78 (65-85), P < 0.001] and post 5 min [74 (63-85), P < 0.001]. LF norm at 10 min [68 (54-82)]

Table 1. Interquartile range (median, Q1-Q3) for diastolic blood pressure (a), systolic blood pressure (b), HR (c), SDNN (d), RMSSD (e) and pNN50 (f) values in platelet apheresis donors at 5 min before apheresis (pre 5 min), at 10th and 45th min during apheresis, and 5 min after apheresis (post 5 min). Different letters denote significant differences. HR, heart rate; SDNN, standard deviation of NN intervals; RMSSD, root mean square of successive RR interval differences; pNN50, percentage of successive RR intervals that differ by more than 50 ms.

Variable	Pre 5 min	10 min	45 min	Post 5 min
Blood pressure (mmHg)				
Systolic	111(106-120)a	-	-	107(99-115)b
Diastolic	71 (65-78)a	-	-	70(64-76)a
Heart rate (bpm)	79(72-88) ab	79(73-86) a	82(76-88)c	77(71-83)db
Heart rate variability				
Time domain parameters				
SDNN (ms)	43(31-59)a	38(27-54)b	32(23-43)c	36(27-52)b
RMSSD (ms)	29(20-46)a	26(17-40)b	19(12-27)c	24(15-35)d
pNN50 (%)	7.5(1.6-21.4)a	3.2(0.6-17.5)b	1.1(0.3-5.1)c	2.5(0.4-11.4)d
Frequency domain parameters				
TP (ms2)	1728(925-3136)a	1368(672-2726)b	997(513-1829)c	1264(694-2387)d
LF (ms^2)	580(262-1196)a	486(249-945)b	430(227-783)c	552(228-1030)a
HF (ms^2)	323(129-723)a	221(89-527)b	138(48-287)c	191(66-500)d
LF/HF (ms^2)	1.9(1.1-3.2)a	2.1(1.2-4.5)b	3.5(1.8-5.9)c	2.8(1.7-5.6)d
LF norm	65(52-76)a	68(54-82)b	78(65-85)c	74(63-85)d
HF norm	35(24-48)a	33(18-46)b	23(15-36)c	26(15-37)d

HR, heart rate; SDNN, standard deviation of NN intervals; RMSSD, root mean square of successive RR interval differences; pNN50, percentage of successive RR intervals that differ by more than 50 ms; TP, total power; VLF, absolute power of the very-low-frequency band; LF, absolute power of the low-frequency band; HF, absolute power of the high-frequency band; LF/HF, ratio of LF-to-HF power (17).

was statistically different with 45 min [78 (65-85), $P < 0.001$] and post 5 min [74 (63-85), $P < 0.001$]. LF norm at 45 min [78 (65-85)] was statistically different with post 5 min [74 (63-85), $P < 0.001$] (Figure 2.). HF norm at pre 5 min [35 (24-48)] was statistically different with 10 min [33 (18-46), $P < 0.001$], 45 min [23 (15-36), $P < 0.001$] and post 5 min [26 (15-37), $P < 0.001$]. HF norm at 10 min [33 (18-46)] was statistically different with 45 min [23 (15-36), $P < 0.001$] and post 5 min [26 (15-37), $P < 0.001$]. HF norm at 45 min [23 (15-36)] was statistically different with post 5 min [26 (15-37), $P < 0.001$] (Figure 3 and Table 1).

Correlation Analysis

Correlation analysis of some HRV parameters and some hematological parameters are presented in Table 2.

A statistically significant and positive correlation was found between hemoglobin (Hgb), Hematocrit (Hct), Red Blood Cell (RBC) and HRV parameters. ($P < 0.05$). No statistically significant correlation was found between platelet (PLT), white blood cell (WBC) and HRV parameters ($P > 0.05$).

Discussion

Platelets are of great importance for hemostasis and wound healing [19]. In this study, platelet apheresis significantly changed the HR and HRV parameters by 45th min, after which a slight restoration appeared to occur at 5 min post apheresis. Thus, the current study shows that during the process of platelet apheresis, dynamic changes take place in the activity of sympathovagal system.

Arterial Blood Pressure

Blood pressure (BP) is an important health indicator [20]. In the study, it was observed that donor attitude or anxiety had no effect on the relationship between negative experiences and blood pressure [21]. Hoogerwerf et al. observed an increase in systolic blood pressure towards the insertion of the needle, a decrease during needle disconnection, and then a small increase again [5]. Diastolic blood pressure has showed an increase towards needle insertion, a drop during needle separation and a small increase thereafter [5]. In our study, diastolic blood pressure did not change during platelet apheresis but systolic blood pressure decreased. Studies have emphasized that systolic and diastolic blood pressures may decrease after plasmapheresis [22]. In the platelet apheresis technique, we used, approximately 250-500 ml of blood plasma is taken together with platelets throughout the process and 180 ml saline is injected at the end of apheresis. However, all of the fluid volume lost is not covered. Therefore, changes in HR might be due to volume depletion and addition. Blood pressure (BP) is an important health indicator [20]. In the study, it was observed that donor attitude or anxiety had no effect on the relationship between negative experiences and blood pressure [21]. Hoogerwerf et al. observed an increase in systolic blood pressure towards the insertion of the needle, a decrease during needle disconnection, and then a small increase again (5). Diastolic blood pressure has showed an increase towards needle insertion, a drop during needle separation and a small increase thereafter [5]. In our study, diastolic blood pressure did not change during platelet apheresis but systolic blood pres-

Table 2. Correlation analysis results of some measured heart rate variability parameters, some hematological parameters.

CORRELATION ANALYSIS	Hb	Hct	PLT	RBC	WBC
SDNN (pre 5 min)	0.231 0.03	0.022 0.039	-0.152 0.159	0.193 0.078	-0.179 0.098
SDNN (10 min)	0.345 0.001	0.263 0.013	-0.054 0.614	0.215 0.048	-0.077 0.475
SDNN (45 min)	0.336 0.001	0.312 0.003	-0.033 0.763	0.254 0.02	-0.043 0.696
SDNN (post 5 min)	0.372 0.001	0.363 0.001	-0.112 0.294	0.316 0.003	-0.095 0.377
RMSSD (pre 5 min)	0.208 0.052	0.183 0.087	-0.184 0.086	0.147 0.181	-0.191 0.077
RMSSD (10 min)	0.19 0.074	0.17 0.111	-0.067 0.531	0.157 1.15	-0.16 0.137
RMSSD (45 min)	0.224 0.036	0.209 0.05	-0.098 0.365	0.166 0.131	-0.155 0.151
RMSSD (post 5 min)	0.3 0.004	0.311 0.003	-0.185 0.082	0.288 0.007	-0.135 0.211
pNN50 (pre 5 min)	0.214 0.046	0.183 0.087	-0.21 0.05	0.167 0.129	-0.204 0.059
pNN50 (10 min)	0.197 0.065	0.188 0.078	-0.061 0.572	0.183 0.094	-0.188 0.079
pNN50 (45 min)	0.224 0.036	0.227 0.033	-0.084 0.434	0.169 0.124	-0.122 0.26
pNN50 (post 5 min)	0.266 0.012	0.279 0.008	-0.117 0.281	0.238 0.027	-0.155 0.149
TP (pre 5 min)	0.237 0.026	0.243 0.022	-0.138 0.2	0.199 0.07	-0.179 0.097
TP (10 min)	0.347 0.001	0.266 0.012	-0.038 0.724	0.217 0.046	-0.08 0.46
TP (45 min)	0.339 0.001	0.303 0.004	-0.045 0.675	0.243 0.026	-0.044 0.688
TP (post 5 min)	0.371 0.001	0.361 0.001	-0.117 0.281	0.32 0.003	-0.117 0.284
LF (pre 5 min)	0.29 0.006	0.301 0.004	-0.173 0.108	0.246 0.024	-0.201 0.061
LF (10 min)	0.247 0.02	0.238 0.024	-0.014 0.897	0.184 0.092	-0.194 0.07
LF (45 min)	0.262 0.014	0.234 0.028	-0.036 0.738	0.229 0.036	-0.059 0.587
LF (post 5 min)	0.286 0.007	0.299 0.005	-0.099 0.359	0.282 0.009	-0.156 0.151
HF (pre 5 min)	0.125 0.246	0.13 0.226	-0.098 0.364	0.081 0.463	-0.175 0.105
HF (10 min)	0.147 0.142	0.116 0.279	-0.057 0.596	0.114 0.299	-0.177 0.1
HF (45 min)	0.215 0.044	0.183 0.087	-0.116 0.28	0.133 0.229	-0.162 0.134
HF (post 5 min)	0.25 0.02	0.268 0.012	-0.168 0.119	0.2390.028	-0.125 0.25
LF/HF (pre 5 min)	0.146 0.176	0.146 0.176	-0.022 0.839	0.145 0.189	0.011 0.923
LF/HF (10 min)	0.025 0.816	0.089 0.406	0.069 0.521	0.038 0.727	0.083 0.441
LF/HF (45 min)	0.085 0.432	-0.51 0.636	0.143 0.184	-0.014 0.901	0.139 0.199
LF/HF (post 5 min)	-0.127 0.239	-0.145 0.181	0.22 0.041	-0.106 0.335	0.019 0.863

* Intracellular: Spearman's correlation, P value, SDNN, standard deviation of NN intervals; RMSSD, root mean square of successive RR interval differences; pNN50, percentage of successive RR intervals that differ by more than 50 ms; TP, total power; LF, absolute power of the low-frequency band; HF, absolute power of the high-frequency band; LF/HF, ratio of LF-to-HF power (17). Hgb, Hemoglobin; Hct; Hematocrit; PLT, PLATELET; RBC, Red, Blood, Cell; WBC, White Blood Cell.

sure decreased. Studies have emphasized that systolic and diastolic blood pressures may decrease after plasmapheresis [22]. In the platelet apheresis technique, we used, approximately 250-500 ml of blood plasma is taken together with platelets throughout the process and 180 ml saline is injected at the end of apheresis. However, all of the fluid volume lost is not covered. Therefore, changes in HR might be due to volume depletion and addition. Studies have emphasized that drinking 500 mL of water or isotonic beverage close to phlebotomy may be beneficial in preventing presyncope or syncope reactions in blood donors [23]. In the study performed by applying platelet apheresis to pigs, mean arterial pressure decreased during blood withdrawal [24]. However, it returned after the blood returned, as expected, due to mean arterial pressure reflex responses [24]. However, in our study, fluid replacement and reflex responses could not sufficiently prevent the systolic arterial pressure from falling.

Heart Rate Variability

HRV is a marker of autonomic function; its decrease has been associated with illness [25]. A normal HR reflects the balance in the autonomic nervous system [26]. In our study, HR increased towards the 45th minute of the platelet apheresis process and decreased towards the end of this process. Kamakura and Maruyama conducted a study about HRV changes during blood volume reduction. Although HR increased towards the middle of the process in their study, this increase stopped towards the end of the process [27]. We encountered a similar result during the plateletpheresis process. Hoogerwerf et al. conducted a study in which they followed the blood donors physiologically from the moment they came to the blood donation center until they left this center. In that study, HR increased from the moment the donation started and started to decrease after the end of the process [5]. However, in our study, HR increases until the 45th minute following the initiation of platelet donation, and then begins to decrease. HR may have increased due to decreased blood volume in the first 45 minutes of platelet donation. In the study performed by applying platelet apheresis to pigs, HR increased during blood withdrawal [24]. However, it returned after the blood returned, as expected, due to HR reflex responses [24]. In our study, the reflected effects of the compensation mechanism on HR in body response to plateletpheresis have been seen from the 45th minute.

SDNN is evaluated as one of the important HRV indices and a low SDNN value has been associated with poor health [17, 28]. In our study, while SDNN decreased until the 45th minute, it started to increase later. Yadav et al. did not see any change in SDNN in the HRV follow-up of donors during blood donation (12). In our study, the decrease in the SDNN value until the 45th minute may indicate that this process might be an important in terms of donor health. However, an increase in SDNN value began to be seen towards the end of blood donation. In addition, it seems to be an important situation that after the 45th minute, the SDNN value starts to increase as the HR starts to decrease. We do not know the long-term effect of platelet apheresis on SDNN but the process itself caused significant changes that lend supports for further investigation.

RMSSSD and pNN50 are reported to be parasympathetic components of HRV [12]. In our study, while RMSSD and PNN50 values decreased until the 45th minute in platelet donors, an increase started to be observed afterwards. Yadav et al. conducted a study comparing HRV in whole blood donors. In that study, RMSSD and PNN50 values decreased during and after donation compared to pre-donation period [12]. During the blood donation, Yadav et al. recorded HRV in the 5th minute. However, we recorded HRV at the 10th and 45th minutes during platelet donation. In whole blood donors, the RMSSD value decreased after the removal of the needle, followed by an increase and a final decrease when leaving the donor center [5]. They predominantly attributed these changes in RMSSD to the physiological response to needle insertion. However, observation of changes in RMSSD values after removal of the needle may be a sign that these changes might be the factors beyond needle insertion.

In our study, TP, HF and HF norm values decreased until the 45th minute of platelet donation, and then increased until the end of donation. These are again likely to reflect volume depletion by the process and volume addition (180 ml) at the end of the process. TP indicates total variability and HF reflects parasympathetic activity [29]. Like SDNN, high TP value is also associated with better health status [29]. In the study conducted by Hoogerwerf et al. in whole blood donors, HF value decreased after needle insertion. However, after the end of the donation, it started to rise and then decreased again (5). In the study conducted by Kamakura and Maruyama, during a 10% reduction in blood volume, HF was significantly reduced [27]. In another study on whole blood donors, it was observed that donation did not affect the TP value, but reduced normalized HF values [12]. In our study, the decrease in these values started to increase after the 45th minute.

LF is considered as an index of cardiac sympathetic control [30,31]. A high LF value usually indicates an increase in sympathetic activity [17]. In most physiological situations, sympathetic or vagal activation is accompanied by inhibition of the other, demonstrating the sympathovagal balance [31]. LF/HF is considered as an index for autonomic nervous system balance (30,31). In our study, while the LF and LF/HF values increased until the 45th minute, they started to decrease afterwards at 5th min after completion of apheresis In the study conducted by Kamakura and Maruyama, during a 10% reduction in blood volume, LF/HF was significantly reduced [27]. In the study conducted by Yadav et al., normalized LF and LF/HF values were found to be lower during and after the donation compared to the phase before donation (12). LF has decreased in some studies on donors [5]. The current study shows that heart rate increases until 45th min plateletpheresis and this is accompanied with increased LF/HF. This appears to confirm that the LF/HF ratio might reflect increased sympathovagal balance.

Correlation Analysis

In our study, there was no correlation between PLT, WBC and HRV parameters (SDNN, RMSSD, pNN50, TP and HF). However, we found a positive correlation between Hgb, Hct, RBC and HRV parameters. Also, in general, the strength of this positive and statistically significant relationship was getting stronger during the donation period. It was emphasized that platelet apheresis performed in the studies decreased Hgb, Hct and RBC (32). In other words, Platelet apheresis has a negative effect on erythrogram parameters [32]. Many studies have shown that Platelet apheresis donors have a high risk for iron depletion [33–36]. Therefore, a positive correlation between Hgb, Hct, RBC and HRV parameters also supports this situation. High SDNN and TP values are associated with better health [17, 29]. In our study, while these values decreased during the Platelet apheresis process, the correlation relationship between them and Hgb, Hct and RBC parameters gradually became stronger.

Conclusions

Our findings show that there is both increased sympathetic activity (reflected by LF, LF norm and LF/HF) and decreased parasympathetic activity (reflected by HF, HF norm) up to 45 minutes. However, after the 45th minute of donation, a decrease in sympathetic activity and an increase in parasympathetic activity began to be observed. These changes appear to be due to volume loss throughout the process (250-500 mL) and volume addition (180 mL) at the end of the process. The changes observed during volume loss resemble the changes observed during whole blood donation.

Overall, important changes occur in cardiac autonomous nervous system activity as revealed by HRV analysis, suggesting that this technique could be used for short-term non-invasive evaluation of autonomic balance during apheresis.

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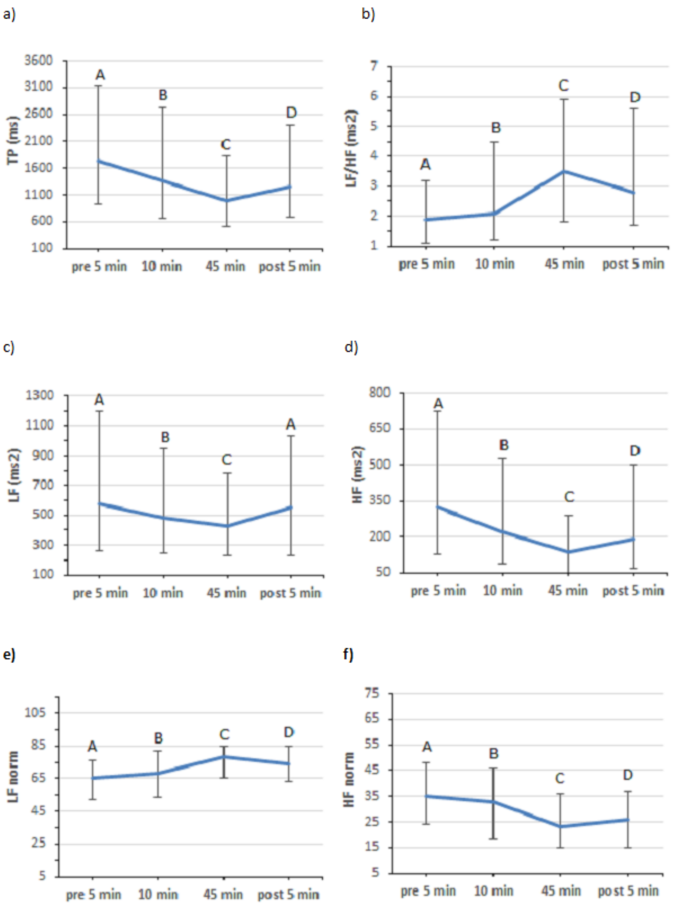

Figure 3. Interquartile range (median, Q1-Q3) for TP (a), LF/HF (b), LF (c), HF (d), LF norm (e) and HF norm (f) values in platelet apheresis donors at 5 min before apheresis (pre 5 min), at 10th and 45th min during apheresis, and 5 min after apheresis (post 5 min). Different letters denote significant differences. TP, total power; LF/HF, ratio of LF-to-HF power; LF, absolute power of the low-frequency band; HF, absolute power of the high-frequency band; LF norm, relative power of the low-frequency band (0.04–0.15 Hz) in normal units; HF norm, relative power of the high-frequency band (0.15–0.4 Hz) in normal units.

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